DFO NEWFOUNDLAND AND LABRADOR REGION SCIENCE REVIEW OF THREE PROPOSED MARINE HARVEST ATLANTIC CANADA MARINE FINFISH AQUACULTURE FACILITIES IN CHALEUR BAY, NEWFOUNDLAND

Context

Marine Harvest Atlantic Canada (MHAC) has submitted applications for three Atlantic Salmon aquaculture licenses in Chaleur Bay, located on the south coast of Newfoundland. As per the Canada-Newfoundland and Labrador Memorandum of Understanding on Aquaculture Development, the Newfoundland and Labrador Department of Fisheries and Land Resources has forwarded these applications to Fisheries and Oceans Canada (DFO) for review and advice in relation to DFO's legislative mandate. The application was supplemented by information collected by the proponent as required by the *Aquaculture Activities Regulations (AAR)*.

To help inform the review of the three MHAC site applications, the Regional Aquaculture Management Office has requested Science to provide advice based on the following questions:

1. Based on the available data for the site and scientific information, what is the expected exposure zone from the use of approved fish health treatment products in the marine environment and the predicted consequences to susceptible species?
2. Based on available data, what are the species at risk, commercial, recreational and aboriginal (CRA) species, ecologically sensitive species (ESS), identified Ecologically or Biologically Significant Areas (EBSAs), and their associated habitats, within the predicted benthic exposure zone, that are vulnerable to exposure from the deposition of organic matter? How does this compare to the extent of these species and habitats in the surrounding area (i.e., are they common or rare)? What are the anticipated impacts to these sensitive species and habitats from the proposed aquaculture activity?
3. To support the analysis of risk of entanglement with the proposed aquaculture infrastructure, which pelagic aquatic species at risk make use of the area, and for what duration and when?
4. Which populations of conspecifics are within a geographic range where escapes are likely to migrate? What are the size and status trends of those conspecific populations in the escape exposure zone for proposed site? Are any of these populations listed under Schedule 1 of the *Species at Risk Act* (SARA)?

This Science Response Report results from the Regional Science Response Process of August 5-7, 2020 on the Review of Three Marine Harvest Atlantic Canada Aquaculture Siting Baseline Assessments, Chaleur Bay, Newfoundland.

Background

Marine Harvest Atlantic Canada (MHAC) has submitted applications to develop new Atlantic Salmon aquaculture sites at three locations in Chaleur Bay, on the south coast of

Newfoundland. Chaleur Bay is in an isolated area with few communities, fishing, or recreational activities. Typical of this area are long narrow bays exposed to the south with steep walls and deep water. The location of the three sites is shown in Figure 1. None of these sites have a previous history of aquaculture activities.

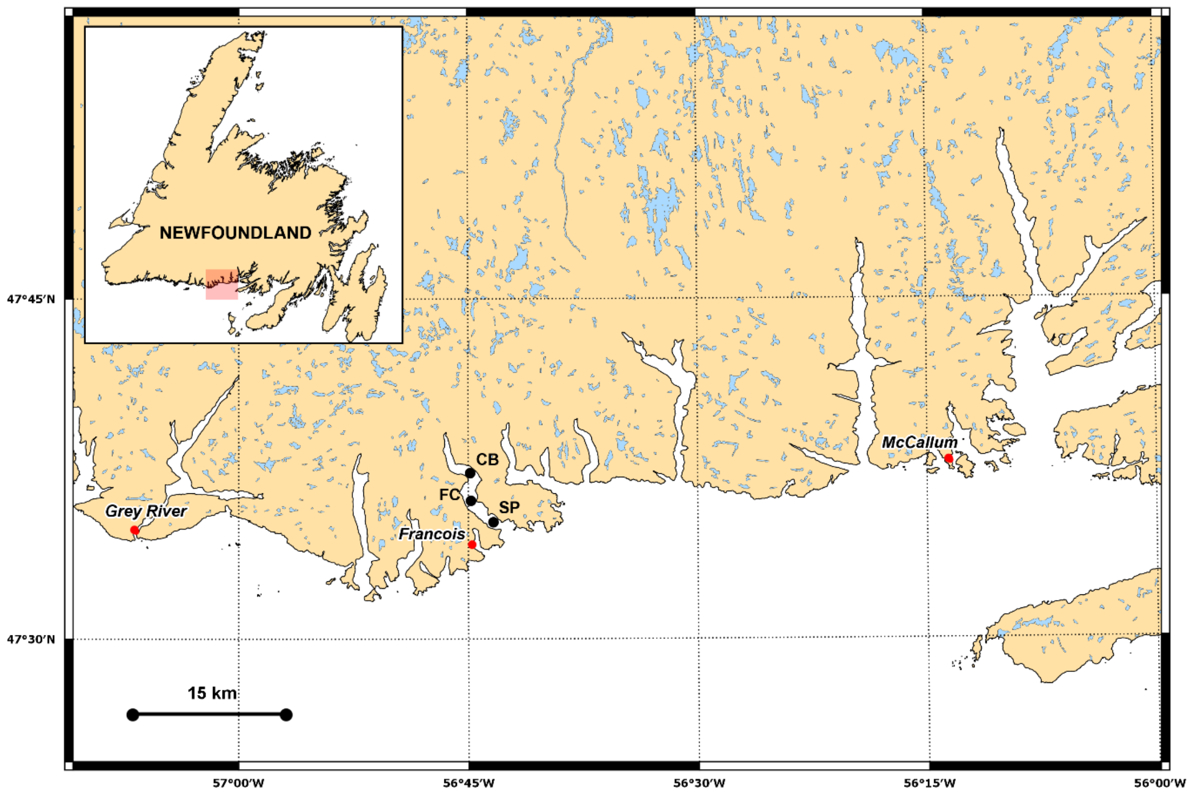

Figure 1: Location of the proposed aquaculture sites in Chaleur Bay, Newfoundland and Labrador (NL). Sites include Chaleur Bay (CB), Friar Cove (FC) and Shooter Point (SP).

General Description of Sites

The three proposed sites are located in the same bay, Chaleur Bay, with sites separated by approximately 2 km. The Chaleur Bay aquaculture site is located approximately 9.5 km north of the town of Francois (by waterway), 41.1 km east of the town of Grey River, and 44.2 km west of the town of McCallum. The proposed lease, as indicated in the baseline report and in the aquaculture license application, is located approximately 5.1 km north northwest of the mouth of Chaleur Bay and is approximately 1,900 m long by 1600 m wide (Table 1). The water depth below the proposed lease area ranges from 1-144 m, with bottom sediments consisting of mixed substrates. Of the 156 stations analyzed, 97 (62%) were classified as hard substrate and 59 (38%) were either soft or fine substrate or a layer of fine substrate over hard bottom. Bacterial mats were reported by the proponent at this site and at Friar Cove.

The Friar Cove aquaculture site is located approximately 7.8 km north of the town of Francois (by waterway), 38.7 km east of the town of Grey River, and 43.1 km west of the town of McCallum. There are cabins used for recreational purposes in this area and there is evidence of associated human activities and wastes, but overall human activity in the area is quite low. The proposed lease, as indicated in the baseline report and in the aquaculture license application, is located approximately 3.5 km northwest of the mouth of Chaleur Bay and is approximately 1,900 m long by 1,400 m wide (Table 1). The water depth below the proposed lease area ranges from 1-266 m and bottom sediments consist of mixed substrates. A total of 199 stations were analyzed at the Friar Cove lease site, with 118 (59%) classified as hard substrate and 81 (41%) classified as either soft or fine substrate or a layer of fine substrate over hard bottom.

The Shooter Point aquaculture site is located approximately 5.6 km northeast of the town of Francois (by waterway), 37.0 km east of the town of Grey River, and approximately 41.9 km west of the town of McCallum. The proposed lease, as indicated in the baseline report and in the aquaculture license application, is located approximately 1.2 km northwest of the mouth of Chaleur Bay and is approximately 1,300 m long by 1100 m wide (Table 1). The water depth below the proposed lease area ranges from 1-282 m with bottom sediments consisting of mixed substrates. A total of 164 stations were analyzed at the Shooter Point lease site, with 118 (72%) classified as hard substrate and 46 (28%) classified as either soft or fine substrate or a layer of fine substrate over hard bottom.

Remotely operated vehicle (ROV) video surveys were used to characterize the flora, fauna, and substrate types within the lease boundaries of the proposed sites. In these surveys, a station is defined as the area of the seafloor surveyed during one minute of video collection. Due to lack of explicit information on ROV speed and camera distance from the seafloor for each specific station, fauna abundances may not be comparable across stations.

There is a commonality in the succession of the epibenthic communities observed at the three sites. At shallower stations close to the coast, video surveys show hard bottom dominated environments with the presence of algae, kelp species, anemones (*Metridium* sp.) and sea urchins; and/or gravel substrates with clams, scallops, and echinoderms (brittle star); and/or sandier areas covered with sand dollars. In deeper areas, steep rock cliffs characterized by areas with little sediment on the seafloor contain mainly anemones, and sponges, while the cliff wall itself supports a high diversity and density of epifauna. The deepest areas of the bay are characterized by soft substrate benthic communities with less taxa richness, including the presence of soft corals (*Gersemia* sp). Proposed cages will be located over a steep slope at each site.

American Lobster (*Homarus americanus*), Snow Crab (*Chionoecetes opilio*), Toad Crab (*Hyas araneus*) and Sea Scallop (*Placopecten magellanicus*) are the most significant commercial benthic invertebrate species in the general area adjacent to Chaleur Bay. Commercial groundfish and pelagic fisheries in the area include Atlantic Cod (*Gadus morhua*), Witch Flounder (*Glyptocephalus cynoglossus*), Greenland Halibut (*Reinhardtius hippogloissoides*), American Plaice (*Hippoglossoides platessoides*), Herring (*Clupea harengus*) and Capelin (*Mallotus villosus*). Data on groundfish and pelagic species are limited for the project area. The DFO spring multi-species survey is typically used to describe the distribution and abundance of species in the NL Region, including the south coast. This survey is completed in three strata adjacent to Chaleur Bay; however, the survey does not extend into this bay, nor any other inshore bay.

The proponent's submission lists Blue Whale (*Balaenoptera musculus*), Fin Whale (*Balaenoptera physalus*), Leatherback Sea Turtle (*Dermochelys coriacea*), North Atlantic Right Whale (*Eubalaena glacialis*), Northern Wolffish (*Anarhichas denticulatus*), Spotted Wolffish (*Anarhichas minor*), Atlantic Wolffish (*Anarhichas lupus*), and White Shark (*Carcharodon carcharias*) as the aquatic Species at Risk potentially found in the Chaleur Bay area. Considering that wild Atlantic Salmon (*Salmo salar*) migrate along the south coast, (and beyond), and are currently designated as Threatened by the Committee on the Status of

Endangered Wildlife in Canada (COSEWIC), they should also be included in this discussion, even though they are not formally listed under Schedule 1 of SARA. Similarly, Common Lumpfish (*Cyclopterus lumpus*) are also present in the area and currently designated as Threatened by COSEWIC, also warranting a discussion despite not being listed under Schedule 1 of SARA. In 2010, COSEWIC designated Deepwater Redfish (*Sebastes mentella*) as Endangered, and Acadian Redfish (*S. fasciatus*) as Threatened. As Acadian Redfish were present in the video surveys, this species should also be discussed here.

Among non-commercial benthic invertebrate species, some of the taxa reported in Chaleur Bay include soft corals, cerianthid anemones, geodiid sponges (further referred to as geodiid-like, due to uncertainty regarding the identity of these sponges), *Hormathia* sp. anemones, brittle stars and feather stars (Appendix 1-3 of MHAC supporting documentation). High concentrations of soft corals (>20 colonies per station) were identified at the Chaleur Bay and Friar Cove sites, and in lower concentrations at Shooter Point. Soft corals can be indicators of vulnerable marine ecosystems (VMEs: FAO 2020, Long et al. 2020). They can provide habitat to other species and enhance local diversity (Baillon et al. 2012, Long et al. 2020, Neves et al. 2020). Long et al. (2020) have recently suggested that a threshold of 1 colony/m^2 can be indicative of a soft coral garden habitat in West Greenland, which can indicate the presence of a VME. Certain sponges and cerianthids can also be considered VME indicators (Murillo et al. 2011). When found in high densities, benthic organisms including the ones listed above might also play a role in providing ecosystem services related to habitat provision and biogeochemical cycling (Migné et al. 1998, Lefebvre et al. 1999, Metaxas and Giffin 2004, Lebrato et al. 2010, Cathalot et al. 2015). Therefore, we produced maps on the distribution of these taxa based on abundance per station as provided by the proponent (section Benthic Predicted Exposure Zones) because they were often observed in high concentrations. Other benthic taxa were also reported for those areas.

The proposed sites do not fall within any previously identified EBSA or Significant Benthic Area (SiBA). The nearest EBSA (South Coast EBSA) and SiBA (for sea pens) are located at 40 km and 20 km from the mouth of Chaleur Bay, respectively. As discussed previously, DFO multispecies surveys do not sample inside this bay, and benthic habitats and communities in this area have not been studied.

Table 1: Key oceanographic, farm infrastructure and grow-out information for the proposed sites. All information was extracted from the reports provided by the proponent for the site licence applications.

Characteristic	Chaleur Bay	Friar Cove	Shooter Point
Dimension [m]	*1900 x 1600*	*1900 x 1400*	*1300 x 1100*
Area [ha]	*130.6*	*171.4*	*125.4*
Net-pen array configuration	*2 x 5*	*2 x 5*	*2 x 5*
Individual net-pen circumference [m]	*140*	*140*	*140*
Net-pen volume [m^3]	*467,844*	*467,844*	*467,844*
Depth under the lease area [m]	*1 - 144*	*1 - 266*	*1 – 282*
Depth under the cage array [m]	*109 - 140+*	*173 – 250+*	*113 – 260+*
Net-pen depth [m]	*30*	*30*	*30*
Current speed [10^{-2} m/s]			
• ***Surface (0-30 m)***	*0 – 27*	*0 – 52*	*0 – 62*
• ***Midwater (30m to ADCP range)***	*0 – 21*	*0 – 33*	*0 – 38*
• ***Bottom (near bottom)***	*0 – 11*	*0 – 9*	*0 – 13*
Predominant substrate type	*Hard bottom*	*Hard bottom*	*Hard bottom*
Grow-out period [month]	*28*	*28*	*28*
Maximum number of fish on site	*1,000,000*	*1,000,000*	*1,000,000*
Initial stocking number [fish/pen]	*100,000*	*100,000*	*100,000*
Average planned harvest weight [kg]	*6.05*	*6.05*	*6.05*
Expected maximum biomass [kg]	*5,747,500*	*5,747,500*	*5,747,500*
Maximum stocking density [kg/m^3]	*15*	*15*	*15*

Analysis and Response

Sources of Data

Information to support this analysis includes data and information from the proponent, data holdings within DFO, publicly available literature, and registry information from the SARA database.

The following supporting information was submitted to DFO for each of the three sites, and was used in this review:

1. Marine Harvest Atlantic Canada Aquaculture Licence Application-Finfish Cage Culture;
2. Baseline Assessment Report, including Benthic Videos;
3. Appendix 1: Logistical Considerations for Salmon Farming in the Bays West Area;
4. Appendix 2: Site Diagrams;
5. Appendix 3: Site Development Plans;
6. Appendix 4: Fishing and Recreational Activities;
7. Appendix 5: Environmental Management and Waste Management Plan;
8. Appendix 6: Environmental Management: Wild Species;
9. Appendix 7: Management of Wild and Farmed Salmon Interactions;
10. Appendix 9: Salmon Fish Health Management;
11. Appendix 10: Site Water Quality Data; and
12. Cleanerfish Health and Welfare Manual.

In addition, the DFO Multi-species Research Vessel (RV) Survey database was referenced to supplement commercial fisheries information provided in the proponent's submissions.

Benthic Predicted Exposure Zones

The Benthic Predicted Exposure Zone (benthic-PEZ) is a triage-analysis based approach. It is computed to provide an order of magnitude of the potential benthic area that could be impacted by the deposit of waste feed and feces associated with aquaculture activities. The PEZ approach has previously been used in DFO Maritimes and NL Regions as part of the review of aquaculture site licensing requests. In the present review, the parameters used for the calculation of PEZ have been selected to reflect the potential effect of the complex water structure found in the region and to ensure a precautionary approach. This initial first-order estimate is used to broadly assess the likely impacts on the benthic community and seafloor from the deposit of waste feed and feces, which can result in organic loading and direct habitat and infaunal species impacts. The exposure zone associated with the release of in-feed drugs is assumed to be dominated by the waste of medicated feed and feces. Benthic exposure can also occur in relation to the use of bath pesticides particularly at shallow depths, however, this will be considered in the Pelagic Predicted Exposure Zones section of this review.

These PEZs are intentionally conservative overestimates to determine whether or not there is anything within a larger area of concern that warrants further refinement of the spatial extent, intensity and/or duration of anticipated interactions. Otherwise, the PEZ analysis is considered sufficient for analyzing, albeit at a larger spatial scale, the likely impacts from the proposed activity.

The area potentially affected depends on various factors including farm layout, feeding practices, sinking velocities of the various particles that can fall out of the aquaculture farm, as well as the physical environment including bathymetry and water currents in the area. The calculation of the benthic-PEZ was carried out with the following assumptions: the current speed is uniform in the whole area, the current directions are radial and pointing away from the center of the cage array, and the bathymetry is constant. Sinking rates were obtained from previously reported values (Findlay and Watling 1994, Chen et al. 1999, Cromey et al. 2002, Chen et al. 2003, Sutherland et al. 2006, Skøien et al. 2016, Bannister et al. 2016). A precautionary approach was taken for the present analysis using slow sinking velocities (the slowest values obtained from the literature), fast water currents (the highest current speed measured at the location and within the layer where the particles will sink), and deep bottom topography (the greatest depth under the cage array). This ensures a maximum possible extent for the exposure zone. The benthic-PEZ is then represented by a circle centered on the cage array.

The proponent provided time series of currents at various depths within the water column, as collected by the Acoustic Doppler Current Profilers (ADCP). The analysis of the current speed data at different depths shows structure with at least three layers for Friar Cove and for Shooter Point and potentially two layers for Chaleur Bay (Appendices A, B, and C). This is the result of stratification present in the water column. Similar water structure has been reported in various bays in the South Coast of Newfoundland where finfish aquaculture is present (Donnet et al. 2018ab, Ratsimandresy et al. 2019 and 2020). The maximum current speeds below the surface layer were used for the calculation of benthic-PEZ at Friar Cove and Shooter Point. For the Chaleur Bay site, the maximum current speed below the cage depth was used.

Table 2 outlines the parameters used in the calculation and the results of the benthic-PEZ for both feed and feces particles. Given that the feed particle type has the fastest sinking rate, the feed-based PEZ best reflects the zone in which the greatest intensity of impacts are anticipated, in particular the potential for smothering. A map showing the first-order estimations of the benthic-PEZ using waste feed particles for the three sites is provided in Figure 2. The result shows that there is overlap among the three sites and that the whole arm is potentially exposed to waste from the sites.

Table 2: Parameters and result of the benthic-PEZ calculation for the proposed sites. Sinking rates correspond to the slowest rate to ensure conservative results.

	Chaleur Bay		Friar Cove		Shooter Point	
Particle type	feed	feces	feed	feces	feed	feces
Sinking rate [10^{-2} m/s]	5.3	0.3	5.3	0.3	5.3	0.3
Bottom depth [m]	140		250		260	
Sinking time [x 3600 s]	0.73	12.96	1.31	23.15	1.36	24.07
Max current speed [10^{-2} m/s]	20.7		33.1		38.4	
Depth of maximum speed [m]	45		56		56	
Benthic-PEZ radius [10^3 m]	0.8	9.9	1.8	27.8	2.1	33.5

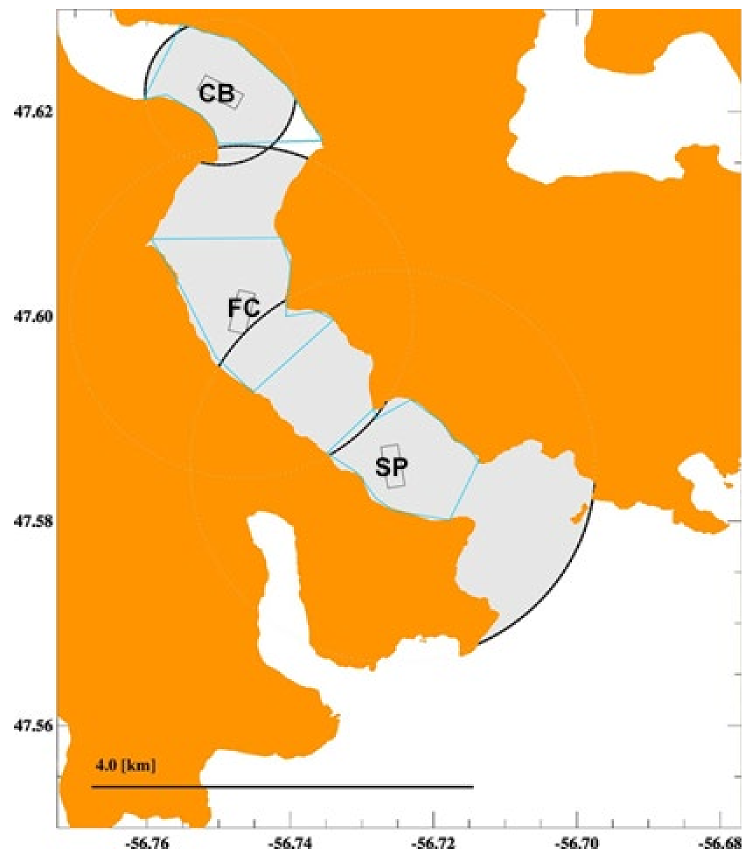

Figure 2: Benthic-PEZ associated with feed particles calculated for each site. Small black rectangles delimit the cage areas and light blue polygons the lease area for each site.

Susceptible Species Interactions

Species are considered to be susceptible within the benthic-PEZ if they are sessile at any life stage and are sensitive to either low oxygen levels, smothering, loss of access to the site, or exposure to in-feed drugs (DFO 2022). Specific consideration is given to whether or not there is evidence in the baseline survey, scientific literature, and Departmental holdings for presence of certain sensitive sessile species, such as sponges, corals and eelgrass, and critical habitat for *SARA*-listed species. When the available data is limited, consideration as to whether the benthic substrate type is suitable for the growth of these species is considered.

Departmental holdings of biological data from the general area is of low spatial and temporal resolution and is too sparse to provide a robust indication of seasonality and spatial distribution of the species and habitats in the area, but there is habitat suitable for numerous species. Therefore, the ability to delineate present-day spatial overlaps between species distributions and the benthic-PEZ for the three sites is limited. There is no identified marine Critical Habitat within the PEZs; however, available information indicates that corals, sponges, American Lobster, and scallops are present within the benthic-PEZ.

There is an overlap between the feed-based benthic-PEZ for Friar Cove and Shooter Point with the adjacent sites (Figure 2) suggesting the potential for cumulative exposure to organic enrichment and feed chemical residues, including drug residues. The feces-based benthic-PEZ (based on smaller, lighter particles) overlaps for all sites and extends to areas beyond the Bay. Note that the PEZ calculation does not provide any estimate of the of the organic loading under the site.

MHAC indicates in its Fish Health Management documentation (Appendix 9) that the potential usage of chemical treatments will be prescribed in combination with a series of alternative treatments (lice guards, cleaner fish, thermolicer, flusher). The drugs listed are two in-feed anti-lice medications: Emamectin Benzoate (EMB) used in cages and lufenuron employed only in the hatchery setting. Specific considerations have to be given to the potential for interactions with crustaceans due to their susceptibility to EMB (Burridge 2013, Environment Canada 2005) and lufenuron (Brock et al. 2018). Once in sediments, EMB is persistent with a minimum half-life of 404 days (Benskin et al. 2016) but might be present for longer periods in weathered sediments and at the NL lower temperatures (Hamoutene and Salvo 2020). Administration of lufenuron occurs in the hatchery; it is expected that one main route of entry into the environment will be in excreta from fish with the released lufenuron present in feces (McHenery 2016). Little is known about lufenuron toxicity or persistence in the marine environment. As crustaceans are susceptible species to the anti-sea lice drugs (and pesticides), specific consideration of the presence of crustaceans is warranted. Lobsters were not observed within the Bay during the baseline survey even they are actively fished (lobsters may hide when the ROV is approaching) however, the presence of shrimp, Toad Crabs, and Snow Crabs within the benthic-PEZ show a potential for these species to be impacted by the deposition of feed/medicated feed (when applicable). Additionally, the persistence of chemotherapeutants in sediments (Hamoutene et al. 2018a) and recovery time of benthic communities (Salvo et al. 2017, Verhoeven et al. 2018) after the aquaculture activity ceased have been reported to be longer than the fallow period planned by the industry (seven months). Further considerations regarding these interactions should be part of the request for chemical usage as part of the provincial regulatory framework for drugs and pesticides.

Both corals and sponges are considered “sensitive and susceptible to anthropogenic activities, including direct (e.g. removal or damage) and indirect (e.g. smothering by sedimentation) impacts” (DFO 2010). Analysis of the baseline video surveys showed that soft corals, sponges, and other sessile organisms are present at all three sites. Given the overlap in benthic-PEZ at Friar Cove and Shooter Point, the benthic species found in the overlap zone, particularly close to the cage array and within the lease boundaries, may be subject to increased organic enrichment and feed chemical residues compared to the other areas within the PEZs.

Video Analysis – Chaleur Bay Site

Maximum reported taxa richness per station was 10, at transect 1 and 2 at ~100 m depth (Figure 3A). The highest taxa richness was identified between transects 1-3 and 12-17. Maximum reported taxa richness per station inside the cage array boundaries was five, most of them fish: Acadian Redfish (N = 1), Winter Flounder (N = 2), Toad Crab (N = 1), Shrimp (N = 1), Snake Blenny (N = 3). Among commercial species, individual Acadian Redfish, Snow Crabs and Sea Scallops (*Plactopecten* sp.) were observed at this site.

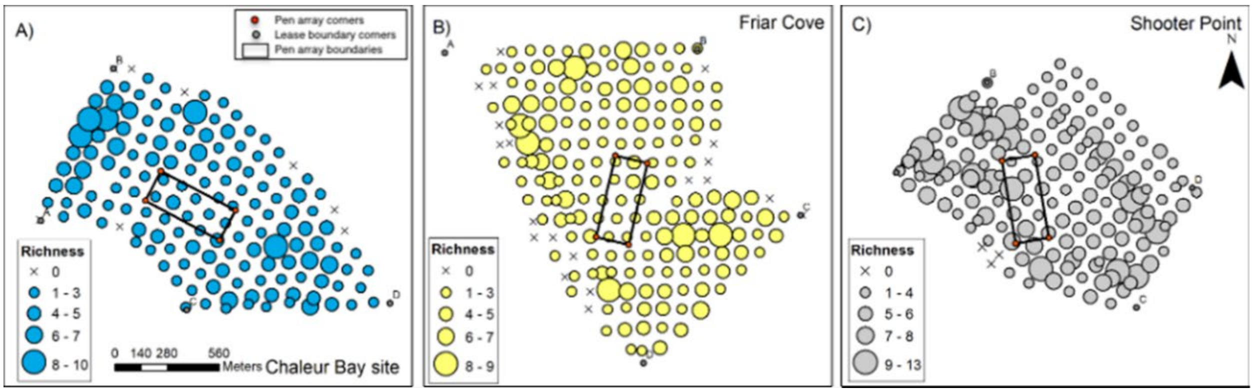

Figure 3: Benthic megafauna richness per station at the three proposed sites in Chaleur Bay: A) Chaleur Bay site, B) Friar Cove, C) Shooter Point. Abundance represents raw counts, and has not been standardized in relation to area covered at each station.

The largest concentrations of soft corals were reported near the Northwest end of the lease area (96-121 m), although they were also observed in smaller concentrations at other areas (Figure 4A). These clusters represent >20 soft coral colonies per station. Although area was not calculated for each station, based on the potential surveyed area ranges of 0.81-23 m^{-2} per station (suggested earlier in this document), it is possible that stations with >20 soft corals could represent concentrations of 0.9-25 colonies.m^{-2}. Considering the Long et al. (2020) definition of a soft coral garden (1 colony.m^{-2}), these areas could constitute such gardens. In the area under the proposed cage array, soft coral concentrations were identified at one station only (N = 2).

Large concentrations of cerianthid anemones were more widespread through the lease area. These clusters represent between 7->20 cerianthids per station, noted only in shallow waters in the west portion of the lease (1 m water depth), and at ~50-60 m towards the east side of the lease (Figure 4B). Cerianthids were not reported at the stations under the proposed cage. Certain cerianthids can also be considered indicators of vulnerable marine ecosystems (VME) when found in high densities (Murillo et al. 2011). In some cases, they were too small or the video quality was too low for them to be detected when the camera was off-bottom, and could only be detected under camera zoom. This means that some accounts of cerianthids are likely an underestimation of their abundance (e.g. Transect 3, station 700 m).

A cluster of geodiid-like sponges was identified in the northwest of the lease area, between 81 to 101 m (Figure 4C). These clusters represent between 10 and >20 sponges/station. At other surveyed areas at this site, geodiid-like sponges were reported at low abundances and not reported under the proposed cage array. In some cases, the accuracy of the taxonomic identity of these organisms as sponges is doubtful. For instance, in transect 2, time 17:17:30, it is difficult to determine that there were >20 geodiid like sponges in that portion of the video, as indicated in the report, considering that it is difficult to properly visualize them. Sponge diversity as identified by the proponent was low, with only seven taxa. Other than geodiid-like sponges, other taxa include unidentified sponges in small abundances (e.g. Vase sponge, N = 1/station).

The sea anemone *Hormathia* sp. was also identified in high concentrations at this site. At most stations, >20 individuals per station were reported (Figure 4D). Video observations indicate that in some areas these sea anemones are the dominant megabenthos. Similarly to the other groups mentioned above, *Hormathia* sp. anemones were less common in the area under the proposed cage array. Ophiuroids were reported in high concentrations at several stations (>20 individuals per station), but not in the area under the cage (Figure 4E). Feather stars were not reported at this site (Figure 4F).

Presence of white bacterial mats was noted in one station (Figure 6) likely as the result of the degradation of naturally deposited organic matter. Patches are relatively small and not continuous and will likely not significantly impact any further evaluations of visual indicator presence as per the post deposition AAR monitoring at peak biomass.

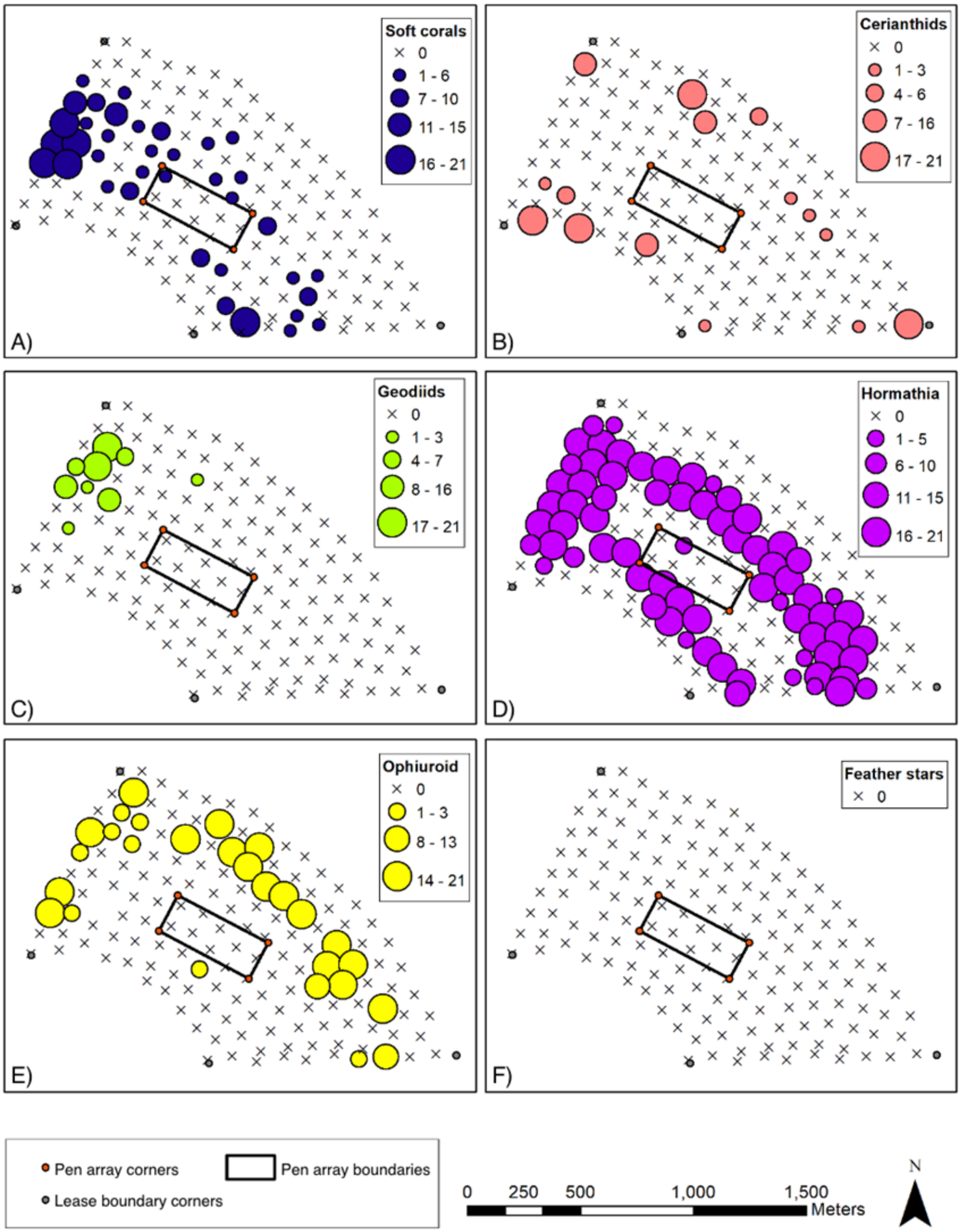

Figure 4: Benthic megafauna abundance at Chaleur Bay site. Abundances of 21 represent the class >20 individuals. Abundance represents raw counts, and has not been standardized in relation to area covered at each station.

Video Analysis – Friar Cove Site

The proponent reported that individual Atlantic Cod, Snow Crabs and Sea Scallops, two schools and individual Acadian Redfish were observed at the Friar Cove site. No juvenile fish habitat or eel grass were reported. One individual Atlantic Wolfish, a species listed under SARA as being of Special Concern, was observed, at ~600 m from the proposed cage array. Kelp beds and brown algae beds were observed at a distance from the proposed location of the cage array.

At Friar Cove, maximum reported taxa richness per station was 9. The highest taxa richness was identified between transects 1-3 and 12-17 (Figure 3B). Maximum reported taxa richness per station under the cage array boundaries was four at two stations: station 400 (T10): Shrimp (>20), Worm Tube (6), Acadian Redfish (1), Unidentified Skate (1), and station 400 (T11): *Hormathia* Anemone (7), Shrimp (>20), Acadian Redfish (1), Worm Tube (5). These two stations are 100 m apart.

Large concentrations of soft corals were mostly identified at the north end of the lease area, and southeast of the proposed cage array area. These clusters represent areas with >20 soft coral colonies/station. Similar to the Chaleur Bay site, these stations with >20 soft corals could represent concentrations of 0.9-25 colonies.m^{-2} which could constitute soft coral gardens according to the Long et al. (2020) definition. No large concentrations of soft corals were identified under the proposed cage array, where there was only one record of a soft coral at 206 m (Figure 5A). In our review of the videos, soft corals were also consistently identified at sites between stations. This is the case of transects 6, 9 and 12, for example, where examination of videos indicated their presence, in some cases in high abundances (e.g. T12, 18:38:09).

No large concentrations of cerianthids were identified at this site (Figure 5B), but large concentrations of *Hormathia* anemones were identified throughout the entire area, although less common in the basin of the bay, where the proposed cage array is located (Figure 5D). Large concentrations of *Hormathia* anemones are also present within the benthic-PEZ overlap area from Shooter Point, where organic enrichment from both sites may occur.

Mapping of the seafloor observations reported by the proponent indicates a cluster of geodiid-like sponges along transects 3-4, 8, and 14 (Figure 5C) . These clusters represent areas of >20 sponges per station. Geodiid-like sponges were not reported in the area under the cage.

Ophiuroids were present in the areas around the cage array (Figure 5E), and crinoids were identified at two stations, but not in high concentrations with none of them in the area under the proposed cage array (Figure 5F). Ophiuroids are also present within the benthic-PEZ overlap area from Shooter Point, where organic enrichment from both sites may occur.

As observed at the Chaleur Bay site, stations located within the cage array boundaries at this site also have generally less megafauna abundance in terms of sponges, soft corals, cerianthids, *Hormathia* anemones, and ophiuroids (Figure 5). The fauna identified under the proposed cage array includes: shrimp, Toad Crabs, worm tubes, *Hormathia* anemones (one station). One redfish and one skate were also reported here. The presence of shrimp and crab within the benthic-PEZ highlights a potential for these species to be affected by the deposition of medicated feed and feces (when applicable), depending upon the amounts of active ingredients used, the frequency and timing of usage, and the standing biomass to be treated.

Presence of white bacterial mats were also noted at one station likely as the result of the degradation of naturally deposited organic matter (Figure 6). As with the Chaleur Bay site, patches are relatively small and not continuous and will likely not significantly impact any further evaluations of visual indicator presence as per the post deposition AAR monitoring at peak biomass.

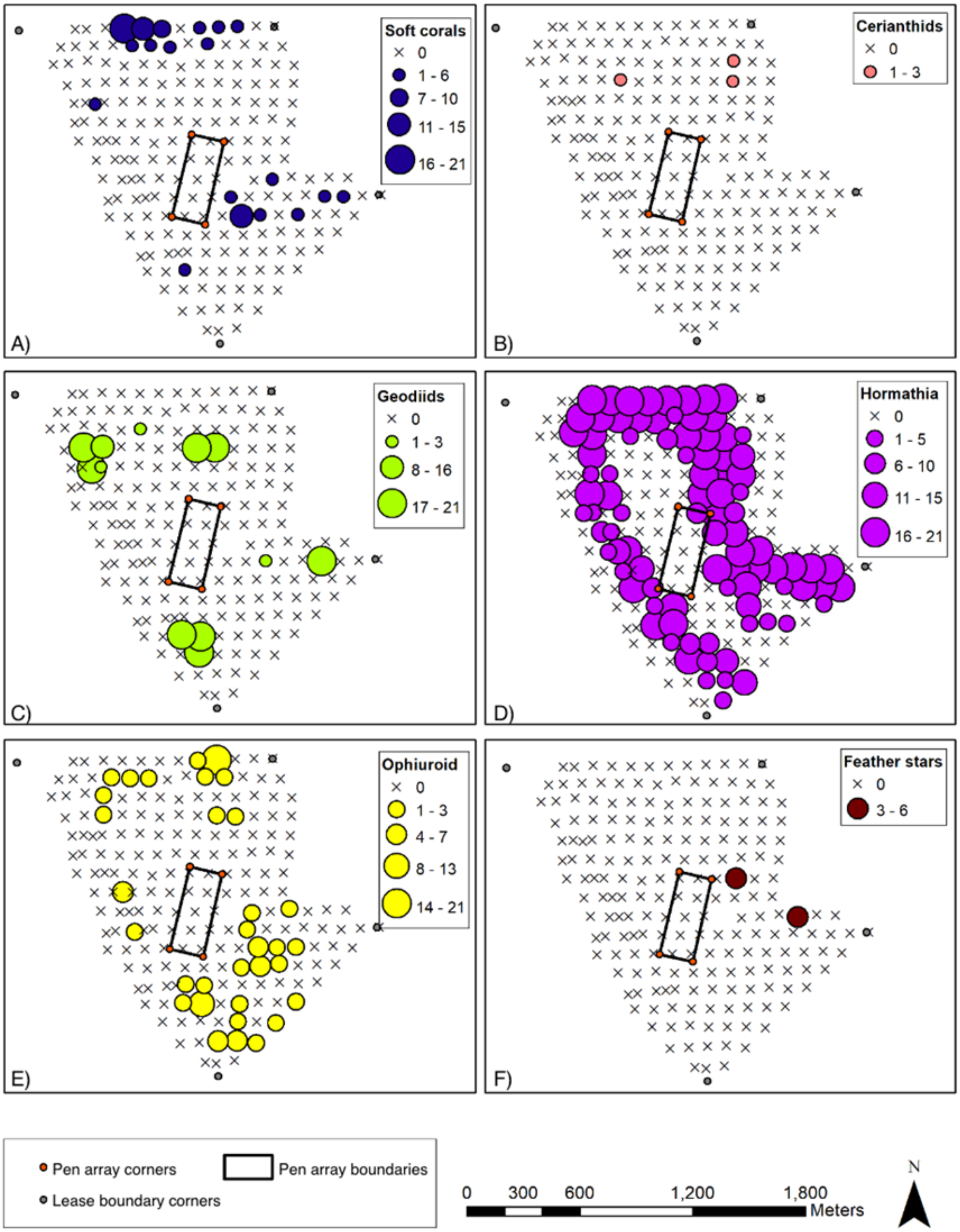

Figure 5: Benthic megafauna abundance per station at Friar Cove. Abundances of 21 represent the class >20 individuals. Abundance represents raw counts, and has not been standardized in relation to area covered at each station.

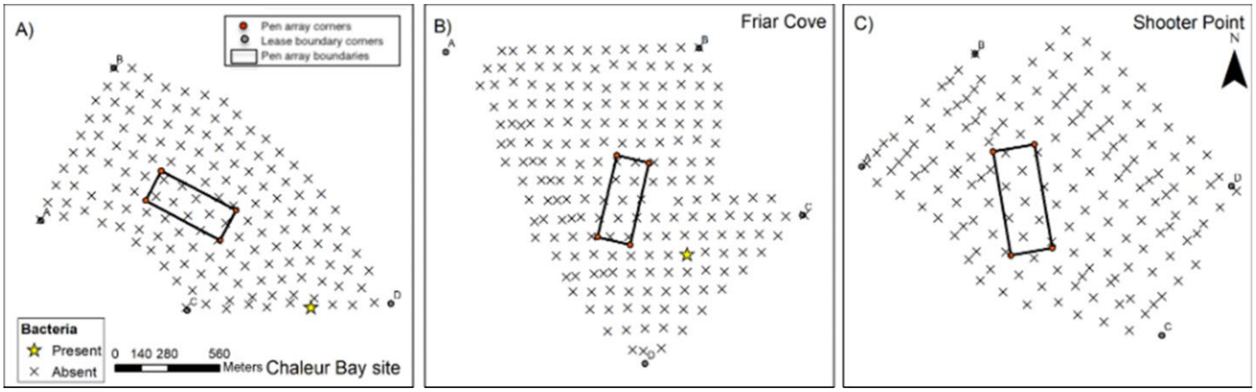

Figure 6: Presence/absence of bacterial mats per station at the three proposed sites in Chaleur Bay: A) Chaleur Bay site, B) Friar Cove, C) Shooter Point.

Video Analysis – Shooter Point Site

The proponent reported that no sensitive species were observed at the Shooter Point site. Four schools of Acadian Redfish, individual scallops, shrimp, and one individual Snow Crab were observed. No juvenile fish habitat or eel grass were reported. No species at risk were observed; and a single bed of kelp, sea urchins and sea anemones as well as two beds of sand dollars were observed at a distance from the proposed location of the cage structure.

Maximum reported taxa richness per station was 13 (Figure 3C). However, taxa richness per station was high throughout the entire lease area, in comparison to the other two sites. Maximum reported taxa richness per station inside the proposed cage array boundaries was nine, at a depth of 208 m. At this station (T9, st. 700), raw abundance was also high in many cases: Geodiidae Sponge (N = 12), *Hormathia* Anemone (N >20), Brittle Star (N >20), Snailfish (N = 1), White Encrusting Sponge (5%), Soft Coral (N = 1), Green Sea Urchin (N = 3), Breadcrumb Sponge (10%), *Serpula* (N >20).

Maximum soft coral counts per station at this site was six, at stations northwest of the proposed cage array. Only one soft coral was reported at stations under the proposed cage array (Figure 7A). A single cerianthid was reported at surveyed stations at this site (Figure 7B). Clusters of geodiid-like sponges were widespread in the lease area (Figure 7C). These clusters represent between 17 and >20 sponges per station. Under the proposed cage array, station 700 (T9) also had a high concentration of sponges (12 individuals), however, no geodiid-like sponges were reported at the remaining stations. Large concentrations (>20 individuals per station) of *Hormathia* anemones (Figure 7D) and ophiuroids (Figure 7E) were identified throughout the lease area, including the area under the proposed cage array.

Feather stars were also reported in high concentrations at several stations in this site, including one station just outside of the cage array boundaries (Figure 7F). In fact, during our review of the videos feather stars were found in very high abundances at transects 10 and 11, with >250 individuals being counted over five minutes of video in both transects.

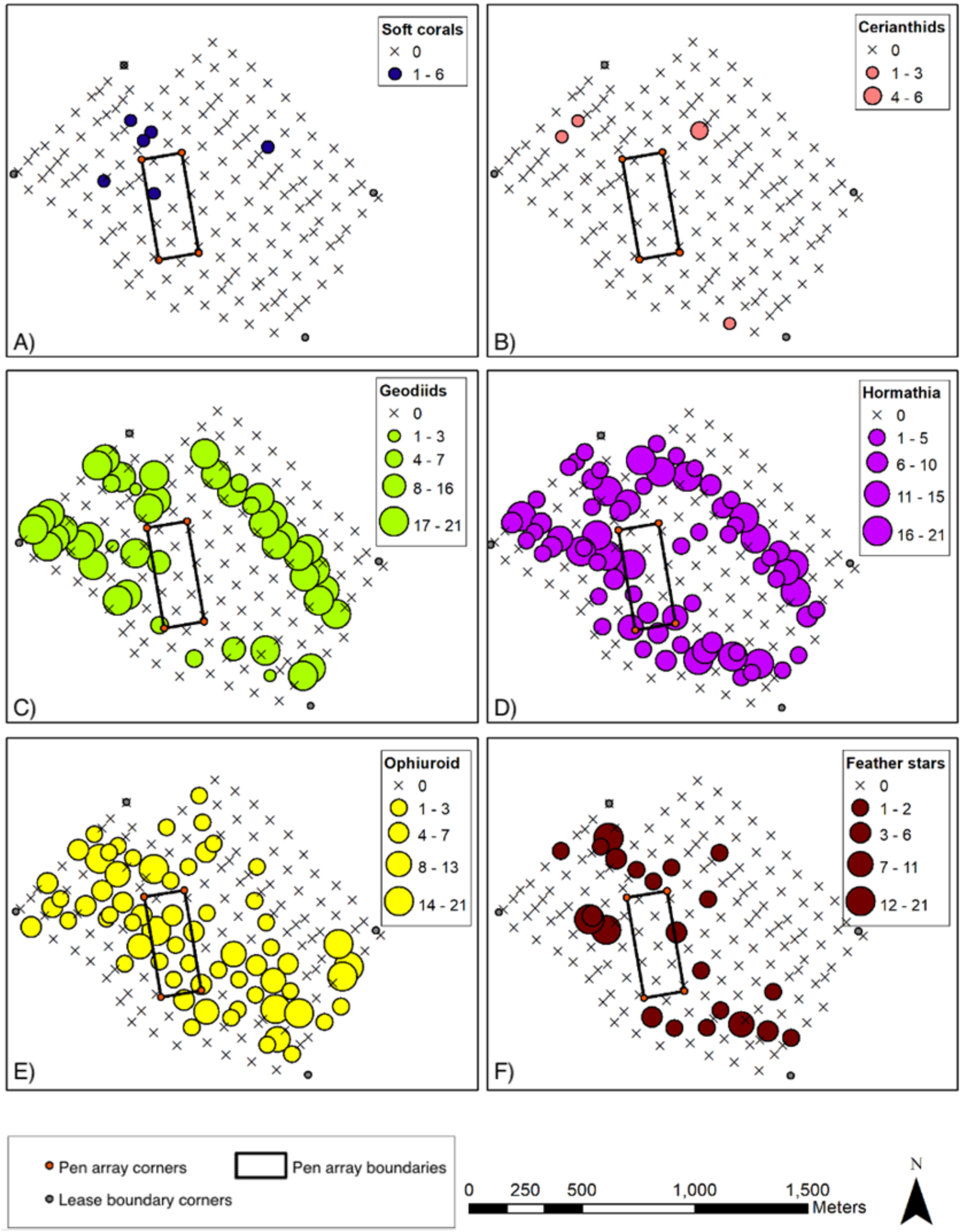

Figure 7: Benthic megafauna abundance per station at Shooter Point. Abundances of 21 represent the class >20 individuals. Abundance represents raw counts, and has not been standardized in relation to area covered at each station.

Pelagic-Predicted Exposure Zone

The Pelagic Predicted Exposure Zone (pelagic-PEZ) is a triage-analysis based approach. An initial first-order estimate is used to predict where interactions between registered pesticides used in finfish aquaculture and susceptible species are likely. These PEZs are intentionally conservative overestimates to determine whether or not there is anything within a larger area of concern that warrants further refinement of the spatial extent, intensity and/or duration of anticipated interactions. Otherwise, the PEZ analysis is considered sufficient for analyzing, albeit at a larger spatial scale, the likely impacts from the proposed activity.

The computation of pelagic-PEZ uses information on the known toxicity of the most toxic of the registered pesticides (i.e., azamethiphos), the predicted dilution and dispersion of the pesticides, and the water currents. Given that the lease areas are in depths ranging from 1 m to over 280 m, with 1 m being in the area closest to the shoreline, dispersion and deposition might be possible in the shallow nearshore should water currents provide the right conditions for transporting the particles towards the shore. The half-lives of the pesticides range from days to weeks, suggesting that they can persist in the environment for some time (Health Canada Pest Management Regulatory Agency [HCPMRA] 2014, 2016ab, 2017).

Treatment occurs within the surface layer (bath treatment or well-boat). Well-boat treatment involves mechanical dilution, this provides a faster dilution rate than for tarp treatments. Given that well-boat discharges are diluted more quickly than tarp discharges, it is expected that potential exposure zones are larger for the latter (Page et al. 2015). The duration of the maximum azamethiphos target treatment concentration of 100 µg/L to dilute to the HCPMRA environmental effect threshold (1 µg/L) is used as the decay and dilution time. For tarp treatment, it is in the range of 3 h (DFO 2013).

As with the benthic-PEZ, a conservative approach was taken and the maximum current speed recorded within the surface layer was used to compute the pelagic-PEZ. It is also the combination of the horizontal transport due to the currents and the length scale of the proposed net pen array. The proponent provided time series of currents at various depths near the surface; however, in the present calculation, maximum current speeds were taken from the depth nearest to the surface and where data only had few gaps or none.

Table 3 outlines the estimated distance from the center of the cage array for the pelagic PEZ as well as the current speed used for the calculation and the corresponding depths where these maximum speeds were recorded. It is noted that the maximum recorded current speed decreases towards the head of the arm.

Table 3: Parameters used to compute the pelagic-PEZ and computed radius of the PEZ.

	Chaleur Bay	Friar Cove	Shooter Point
Depth [m]	8	8	6
Max. current speed [10^{-2} m/s]	24.6	44.3	61.8
PEZ radius [10^{3} m]	2.9	5.0	6.9

Figure 8 illustrates the estimated PEZ for each site. As expected, the faster the current speed, the greater the advection distance of the toxic particles. Under the assumptions used in the calculation, shallow areas along the shore may be at risk of exposure to toxic products released and transported from the proposed sites during the 3 h of evaluation. There is a significant overlap of all the pelagic-PEZ related to the usage of bath pesticides (Figure 8). In particular, the pelagic-PEZ of Friar Cove and Shooter Point extend to waters beyond Chaleur Bay.

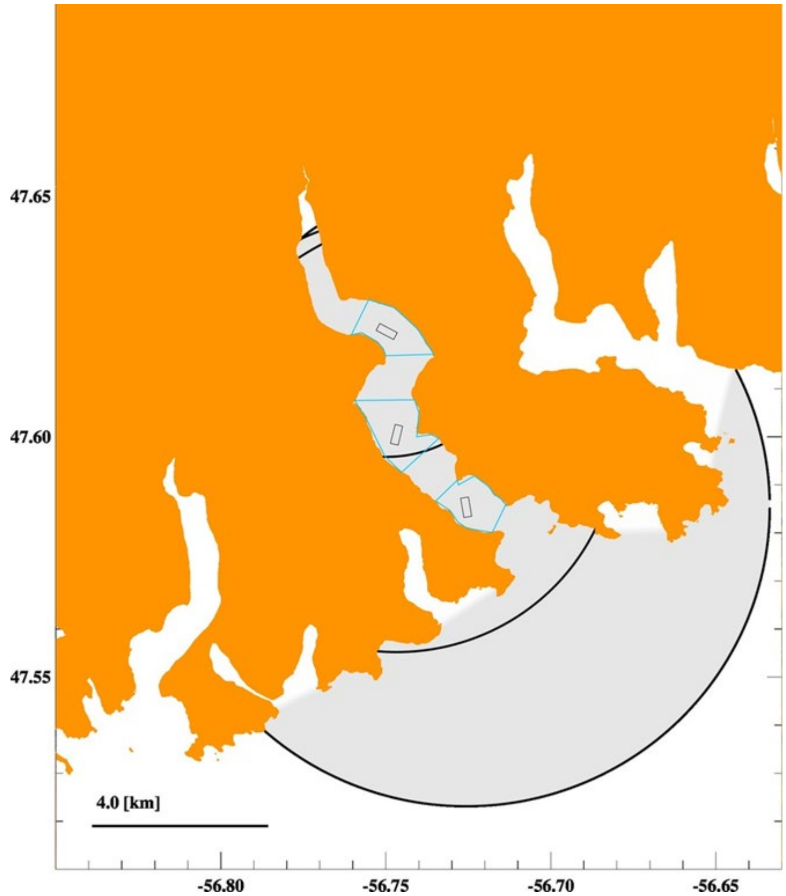

Figure 8: Pelagic-PEZ computed using the maximum current speed near the surface for each proposed site. Inner most circle corresponds to Chaleur Bay site, middle circle to Friar Cove, and largest circle to Shooter Point. Black rectangles delimit the cage areas and blue polygons the lease area for each site.

The pelagic-PEZ shows the potential for particles to reach the shoreline; while the coastal currents have not be measured and will likely be slower than those used in the deep areas, the seabed near the coastal portions of the fjord will be exposed to pesticides, likely from multiple sites. An area-based fish health approach that takes into account the potential for cumulative impacts could mitigate potential effects.

Susceptible Species Interactions

Species are considered to be susceptible within the pelagic-PEZ if they are CRA fisheries species, are SARA-listed species, or have known sensitivities to pesticide exposures. Specific consideration is given to the potential for interactions with crustaceans due to their higher relative susceptibility to the pesticides used in aquaculture.

Departmental holdings of biological data from the general area is of low spatial and temporal resolution and is too sparse to provide a robust indication of seasonality and spatial distribution of the species and habitats in the area. While there was no identified marine Critical Habitat within the PEZs, there is habitat suitable for numerous species.

Analyses conducted by HCPMRA (2016b) concluded that azamethiphos bath and well-boat treatments pose risk levels that are below the established level of concern (LOC) for marine fish, marine mammals and algae, but above the LOC for pelagic and benthic invertebrates.

Azamethiphos is toxic to non-target crustaceans while in the environment, including all life stages of lobster (Burridge 2013, HCPMRA 2016b, 2017). Timing of treatment is important considering that presence of crustacean larvae in the pelagic environment and juveniles in shallower waters is also a factor to consider to reduce potential impact on crustaceans recruitment. Upon hatching during warmer months (June to September) American Lobster larvae move to the upper water column where they begin a free-swimming planktonic phase for 3-10 weeks, depending on environmental conditions (Lawton and Lavalli 1995). The Snow Crab life cycle features a release of larvae in spring followed by a pelagic larvae period in the surface layers that involves several stages before settlement in the fall (Sainte-Marie 1993). Northern Shrimp larvae hatch in the spring (i.e., April-May) and remain pelagic for several months (Bourdages et al. 2020).

Physical Interactions

Benthic Species Interactions

The baseline reports did not report any observations of American Lobster, even though the proposed sites are located within a productive area for this species. The fishing area that extends from Fortune Bay to Port aux Basques accounts for 45% of lobster landings for all of Newfoundland. Lobster in this area are fished in waters up to 90 m, which is significantly deeper than the fishery elsewhere in the province. The non-observation of lobsters during the ROV video surveys could be associated to their cryptic nature (especially during the day), and the unlikelihood of observing these animals during ROV surveys. The baseline assessments did identify suitable lobster habitats at the proposed sites (i.e., boulders, bedrock and kelp). Expansion of aquaculture development at the proposed sites increases the risk of anoxic or hypoxic conditions beneath cages that could impact lobster in the area. Anti-sea lice pesticides are toxic to all lobster life stages. Concern about pesticide exposure is greatest at shallow sites with lower dispersion patterns and more prevalent juvenile lobster presence (Lawton and Lavalli 1995). The pelagic-PEZ indicates that pesticides will be transported to the coastal areas prior to dilution below the known toxic effects level for the most sensitive lobster life stage.

Scallop were observed in the lease area of the three proposed aquaculture sites. Potential exposure to pesticides that target sea lice and deposition under the cages could potentially affect scallop species as observations in other areas where aquaculture operations exist have shown evidence of lower meat to shell ratios (lower meat quality) in scallop and thinner shells (Wiber et al. 2012).

The groundfish data from the DFO spring multispecies survey of the three strata adjacent to the proposed aquaculture sites was reviewed. From 2000-18, a variety of commercial species were encountered in these strata, with up to 20% of Atlantic Cod, up to 16% of Witch Flounder, up to 5% of Greenland Halibut, and up to 2% of American Plaice survey biomass indices in Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps coming from these three survey strata. There is no available information on the movement of these or other groundfish species within Chaleur Bay. The interaction between groundfish and the proposed sites is unknown.

Pelagic Species Interactions

Both past commercial Atlantic Salmon catch data and tag returns indicate that salmon from throughout southern Newfoundland, and likely Atlantic Canada are present along the coast of southern Newfoundland (Reddin and Lear 1990). For example, salmon tagged in St. Lawrence (1973), Placentia Bay (1975), and throughout the east coast were recaptured across the south coast (e.g., Burgeo, Port aux Basques) and throughout the Maritimes. This is further substantiated by the historical data on commercial and recreational catches in southern

Newfoundland (May and Lear 1971, Lear 1973, Reddin and Short 1981, Ash and O'Connell 1987). Recent genetic assignments from the St. Pierre-Miquelon mixed stock fishery (ICES 2020) indicate that the fishery was dominated by contributions from Gulf and Gaspé Peninsula regions and also had a smaller contribution from the Northeast coast of Newfoundland. Although Atlantic Salmon do not seem to reproduce in rivers entering Chaleur Bay, it is likely individuals from southern Newfoundland populations, and from elsewhere, migrate through this area and will be exposed to these sites both as migrating smolts and returning adults.

There have been longstanding and continuous population declines of wild salmon in southern Newfoundland as compared to other regions of the province. In 2019, total salmon returns to two monitored rivers in this area, Conne River and Little River, declined by 78% and 99%, respectively, compared to their previous three-generation average. This trend is against a backdrop of acute and chronic escape events, hybridization with escapees, reported disease outbreaks, and increased need for sea lice control measures, all of which have documented negative impacts on wild salmon populations. Two of the rivers where smolts are counted and marine survival is estimated are in Salmon Fishing Area (SFA) 11 (Conne River and Garnish River) and both show poor marine survival in recent years (<3% in 2018 and 2019) relative to the other three populations that DFO monitors in a similar fashion. At Western Arm Brook, Campbellton River, and Rocky River, mean marine survival rates over the past 10 years range from ~5-9% across rivers.

Figures provided by the proponent show angling sites for Brown Trout (*Salmo trutta*) in Chaleur Bay. This is interesting, but possibly incorrect. Westley and Fleming (2011) do not report any Brown Trout occurring in this area, with the closest populations apparently on the Burin Peninsula. If Brown Trout are indeed found in Chaleur Bay, this should be investigated further.

Capelin are present (Templeman 1948, Dickson 1986, Richard 1987, Dawe et al. 1997), however, they appear to make limited use of the areas included within the proposed lease sites. The main concern for this species would be incidental predation by farmed Atlantic Salmon. Acoustic surveys in NAFO Division 3L indicate that the peak depth for Capelin biomass in spring is generally between 140 and 280 m. Due to the limited vertical overlap between the depth of the salmon cages and the depth range of peak Capelin biomass, the limited portion of Capelin habitat within the area, the potentially limited size of the Capelin stock in the area, and possibly the small mesh size that the proponents are planning to use, the effects on juvenile and adult Capelin should be small. There is the potential that predation by farmed salmon could have a strong negative effect on the larvae of Capelin in the area if spawning does occur, as the larvae occupy the same portion of the water column and are likely small enough to pass through the mesh.

Herring are an important forage species in the region and are present in sufficient numbers to support a commercial fishery (Tibbo 1956, Templeman 1966, Dickson 1986). Due to the positioning of the proposed cages in narrow fjords, the relative position of the water column occupied by Herring and the relative abundance of Herring in the ecosystem, it is likely that wild Herring will move past or interact with cages during the production cycle. Loss of habitat or reductions in productivity due to the presence of the facility is expected to be small. However, potential disease transmission and/or propagation may be of concern as some research indicates Infectious Salmon Anemia Virus (ISAV) is able to propagate in Herring and they may be an asymptomatic carrier of the ISAV (Nylund et al. 2002). Similar to Capelin, Herring larvae may be vulnerable to significant levels of predation by farmed salmon given their small sizes and potential to pass through the small mesh sizes that the proponents intend to use.

Aquaculture Escapees

Recent genetic studies have documented widespread hybridization between wild salmon and aquaculture escapees both in southern Newfoundland and in the Maritimes. Across the North Atlantic, the magnitude of genetic impacts on wild populations due to escaped farmed Atlantic Salmon has been correlated with the biomass of farmed salmon in nearby cages and the size of wild populations. Here the potential genetic interactions resulting from the proposed finfish expansion involving three sites (1M individuals/site) in Chaleur Bay, Newfoundland was considered using a combination of empirical data (North American and European), and both individual-based and dispersal modeling following Bradbury et al. (2020). First, exposure pressure was quantified as propagule pressure as per Keyser et al. (2018). Second, the distribution of escapees in the wild under the current and proposed production regime were modelled using a recently published spatial model of dispersal and survival (Jóhannsson et al. 2017, Bradbury et al. 2020). Model predictions were evaluated against a 10% threshold, above which demographic decline and genetic change have been predicted (Bradbury et al. 2020).

Under the proposed expansion scenario exposure (propagule) pressure is expected to increase by 10-22% in the rivers closest to Chaleur Bay, with the highest increase (22%) in Grey River. The dispersal model predicts a 7.7% increase in escapees overall, and a 12.6% on average increase in escapees from Farmers Brook to Little River (Figure 9). With the proposed expansion, predictions for the proportion of escapees overall in southern Newfoundland exceed 10% escapees relative to the wild population for 20 rivers across the region. Although significant uncertainty exists in the size of wild populations, and both the number and distribution of escaped farmed salmon in the region, sensitivity analyses support the conclusion that there will be an increase in demographic and genetic impacts under the proposed expansion.

A review of the proponent’s Management of Wild and Farmed Salmon Interactions document (Appendix 7) highlighted the omission of a plan for a thorough evaluation of the success of any attempts to limit escapees through an escapee monitoring and traceability program. Without this component, there are no data to evaluate success or failure against, or to evaluate claims made regarding significant gains in reducing escape events. There is precedent in the province to have producers implement a monitoring program (i.e. counting fence per BMA) to evaluate the efficacy of their containment efforts in Newfoundland waters and a similar program could be implemented here. Without that data, the only reasonable course is to assume that rates of escapees are similar to Norwegian-validated estimates.

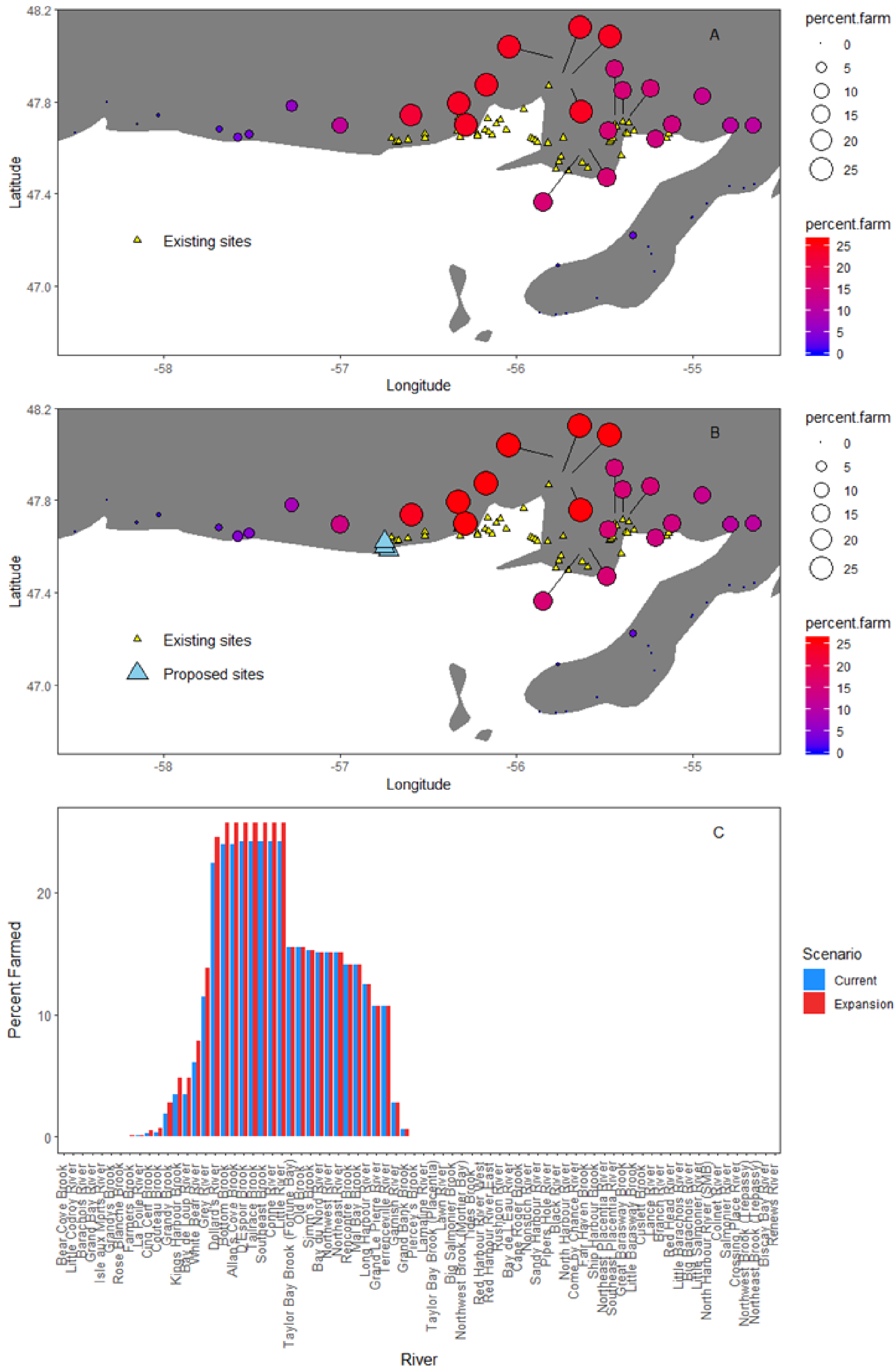

Figure 9: Maps of the percentage farmed escaped salmon relative to wild salmon present, before (A) and following (B) the proposed expansion. (C) River specific estimates of the percentage farmed escaped salmon relative to wild salmon present, both before (blue) and following (red) the proposed expansion.

A traceability program to identify a farmed fish via genetic markers from a tissue sample would be important, regardless of a comprehensive escape monitoring program. Farmed fish are captured at some DFO monitoring sites and it would be useful for documenting the true number of farmed fish that migrate to those counting fences and potentially beyond if they are not accurately identified based on a visual examination of external characteristics. A precedent exists (i.e., with the State of Maine) and procedures for this type of genetic analysis are in place within DFO, moreover DFO labs have capacity to do this work.

Finally, in order to evaluate the proponent’s claim that the high-density polyethylene (HDPE) nets eliminate escape events in Newfoundland waters, data is required from within NL Region, yet no measures have been included in the site application to collect and assess escapees.

Cleaner Fish escapees

Integrated pest management and the continued threat of sea lice represents one of the most significant challenges facing the Atlantic Salmon aquaculture industry worldwide. This threat and the potential ecological impacts are poised to increase as common therapeutants become increasingly ineffective due to the evolution of resistance (Fjørtoft et al. 2020). Cleaner fish such as wrasse and Common Lumpfish are used in aquaculture as a biological control for sea lice in other countries, such as Norway (Blanco Gonzalez and de Boer 2017) and Ireland (Bolton-Warberg 2018). In Atlantic Canada, the industry has begun investigating the use of both Common Lumpfish and Cunners (*Tautogolabrus adspersus*) as cleaner fish with much of the preliminary development work underway in Newfoundland. However, as with Atlantic Salmon (e.g., Wringe et al. 2018), research suggests reproductive interactions between cleaner fish and wild populations warrant consideration as negative impacts are likely (e.g., Faust et al. 2018, Blanco Gonzalez et al. 2019).

Little is known regarding the specific locations of habitat use of wild Common Lumpfish in inshore waters of southern Newfoundland, though it is known that they nest in nearshore bays around the island (Simpson et al. 2016). However, DFO-NL spring multispecies surveys in Subdiv. 3Ps indicate declines in abundance of about 58% between 1996 and 2014 (Simpson et al. 2016). Accordingly, COSEWIC designated Common Lumpfish as Threatened in Canadian waters in 2017 (COSEWIC 2017). Although Lumpfish in Canadian waters were assessed as a single designatable unit (COSEWIC 2017), recent genetic analysis (Ian Bradbury, pers. comm. 2020) suggests significant subdivision is warranted with the presence a northern population which includes southern Newfoundland. There remains considerable uncertainty regarding the potential impact of the proposed expansion on local Common Lumpfish populations. However given the status of this species in the NL Region, and evidence of negative genetic impacts of cleaner fish on wild populations elsewhere, the potential exists for increased negative interactions due to the proposed expansion in southern Newfoundland.

As there is presently no fishery for Cunner, and they are not formally assessed, little is known regarding the status of this species in Newfoundland waters. Given recent evidence that wrasse fisheries for use as cleaner fish can significantly impact wild populations (Halvorsen et al. 2017), it seems plausible that:

1. Fisheries for Cunners may significantly impact wild Cunners in the region; and
2. That interbreeding with escapees could significantly harm wild populations (Faust et al. 2018).

In the absence of abundance data, population structure data, and data on rates of gene flow from aquaculture facilities there remains significant uncertainty as to the potential impact of the proposed expansion on Cunner in the region. It is worth noting that genetic work is currently underway to quantify population structure among Cunner distributed throughout Atlantic Canada and the waters around Newfoundland, specifically, to inform the transfer of individuals for use as cleaner fish in salmon aquaculture.

Pests and Pathogens

When considering the siting of farms, many jurisdictions have limits on the proximity to salmon bearing streams to minimize interactions between wild and farmed salmon, including as it relates to fish health interactions. Additionally, many provinces use a zonation approach (e.g. bay management areas, fish health zones) in their fish health management approach for aquaculture which allows for the coordinated management of fish health. Best practices related to the development and implementation of effective fish health zones or bay management areas are based on a combination of considerations including proximity between farms, pathogen spreading dynamics, and the current velocities that will disperse and dilute pelagic particles released from these farm sites (Chang et al. 2007, Grant and Jones 2010).

The key endemic diseases and pests that Atlantic Salmon farms in Atlantic Canada manage or are presently concerned with are Bacterial Kidney Disease (BKD), Infectious Salmon Anaemia (ISA), and sea lice. BKD is a slowly developing bacterial disease that typically results in chronic infection over months rather than mortality. It is treatable with antibiotics (see Rhodes and Mimeault 2019 for a recent review). In contrast, the virulent form of ISA has been detected on Atlantic Salmon farms along the south coast of NL in recent years, and has required earlier harvest of fish to mitigate risks of viral spread.

Sea lice are small, naturally occurring ectoparasites that can pose a significant health risk to farmed and wild Atlantic Salmon when present at certain host density threshold levels (Krkosek 2010). Density-dependent transmission is observed in many pathogen-host systems, including sea lice on salmon farms (Kristoffersen et al. 2013, Frazer et al. 2012). While salinity and temperature are important parameters that influence development of sea lice, sea lice infestations on Atlantic Salmon farms along the south coast of Newfoundland occur, and the industry uses the available approved drugs, pesticides and alternative methods to control them. Modeling studies have examined critical biomass thresholds to estimate when production levels in an area are likely to result in outbreaks (Frazer et al. 2012). Frazer et al. (2012) estimate this threshold is between 12,000 – 15,000 tonnes for Passamaquoddy Bay, New Brunswick. If this estimate is applicable to the salinity and temperature found in Chaleur Bay, then the planned production of 16,950 to 17,250 tonnes in the Bay can be expected to exceed the area host threshold, which may result in a sea lice epidemic.

Sea lice have been identified elsewhere (e.g., Forseth et al. 2017) as one of the main threats to wild salmon persistence and declines in wild stocks have been attributed to sea lice outbreaks in farm-intensive areas in Ireland, Scotland, Norway, and British Columbia. Thorstad and Finstad (2018) reviewed the literature related to sea lice impacts on wild stocks documenting 12-29% fewer returning adult spawners due to lice-induced mortality from fish farms. Shephard and Gargan (2017) suggested that one sea-winter (1SW) salmon returns on the River Erriff were more than 50% lower in years following high lice levels on nearby farms. Similarly, Bøhn et al. (2020) tagged and released Atlantic Salmon smolts both with a prophylactic treatment against lice, and without such treatment and reported that the mortality of untreated smolts was as much as 50 times higher compared to treated smolts during sea lice outbreaks.

Although no data exists on sea lice-induced mortality in southern Newfoundland, it seems reasonable to expect significant demographic impacts to wild salmon associated with sea lice in southern Newfoundland. The addition of 3,000,000 farmed fish to the area can reasonably be expected to amplify both endemic pathogens and sea lice in the area, due to the significant increase in the number of host fish. The impact on wild susceptible fish species will depend on the duration and extent of their exposure to the new farm sites, the increased concentration of pathogens and parasites, and their relative susceptibility to infection and disease within the environmental conditions found in Chaleur Bay.

Both wild Common Lumpfish and wild Cunner are found in inshore bays along the south coast of Newfoundland, and could also sustain parasitic infections, as well as viral, bacterial, and fungal infections that may be found in cleanerfish species. In addition, certain infections, such as that caused by *Aeromonas salmonicida*, may be passed between Atlantic Salmon and cleanerfish species, potentially resulting in impacts to wild populations of more than one species.

Entanglements

Bycatch or entanglement of wild species (e.g. wild fish, marine mammals, turtles, sharks) associated with the placement of infrastructure is another potential interaction associated with aquaculture sites.

There is a lack of data regarding the distribution of cetaceans and pinnipeds in the Chaleur Bay area, but there is overlap with the distribution of several species of whales and seals in the NL Region. In addition to the SARA-listed marine mammal species discussed earlier, Humpback Whale (*Megaptera novaeangliae*), Minke Whale (*Balaenoptera acutorostrata*) Sei Whale (*Balaenoptera borealis)*, dolphins, Harbour Porpoise (*Phocoena phocoena*), and seals (e.g., Grey Seals [*Halichoerus* grypus] and Harbour Seals [*Phoca vitulina*]) can be found in Newfoundland waters year round, though their abundance in nearshore waters is typically highest from spring to autumn. Some species, such as North Atlantic Right Whale and Grey Seals, are seasonal visitors and are typically absent in winter. The potential attraction to the proposed sites and the potential reduction of haul out space in the area are concerns for pinnipeds. While entanglement and subsequent drowning are the main concerns for marine mammal species which do not echolocate (e.g. baleen whales), the risk of entanglement is considered low at the proposed sites since marine mammal entanglements have never been reported at finfish aquaculture facilities on the South Coast.

Available information indicates that Leatherback Sea Turtles and large pelagic fish species (sharks and tunas) can be found in the area, particularly from spring to autumn. In recent years, an increasing presence of large pelagic species has been observed by both industry and DFO personnel. Predation of tagged farmed salmon by tuna has also been documented in Hamoutene et al. (2018b). Despite the usage of the HDPE Ultracore net systems for predation prevention, the potential exists for entanglements of both sharks and tuna.

AAR Monitoring Standard

Baseline survey requirements under the AAR Monitoring Standard currently lack specificity in a number of areas that affect the quality of the data available for analysis. As written, none of the specifications for operational visual monitoring under the AAR monitoring standard related to image clarity, resolution, field of view, or operation of diver-operated, towed, or remote-operated video cameras apply to the collection of baseline survey information. Consistency in these requirements might have improved issues related to image clarity, field of view and lack of adequate resolution.

If the use of an ROV as a surrogate drop camera is supported by future changes to the AAR Monitoring Standard, the following information should be considered: substantial variability in the range of surfaces covered within a station was identified during this review (from 0.81 m^2 to

25.6 m^2). Guidance to support reporting on surface covered when evaluating abundances is recommended.

Greater specificity in reporting requirements would improve the utility of submitted reports for providing advice. For example, requiring records of abundance would improve the interpretation of benthic community distribution and comparison between stations.

Analysis of video between stations indicates that sampling designs with discreet stations (drop camera) may mask presence of organisms, suggesting that reported absences or low abundances of species in these surveys must be considered with caution. Information regarding the ideal combination of sampling methods at a given spatial scale, habitat, or region to detect biodiversity patterns will help maximize the number and range of specimens collected, as well as the spatial coverage of the collection (Flannery and Przeslawski 2015).

Other considerations/sources of uncertainty

Both corals and sponges are considered “sensitive and susceptible to anthropogenic activities, including direct (e.g. removal or damage) and indirect (e.g. smothering by sedimentation) fishing impacts” (DFO 2010). The statements of “no sensitive species were found” reported by the proponent is not accurate. Soft corals, sponges, and other sessile organisms that are vulnerable to smothering are present at all three sites.

There are several inconsistencies among the various reports (baseline report and appendices) for the same site. The lists of benthic species reported from visual bottom sampling and fish habitat surveys, including the CRA and SARA-listed species often differ among these reports.

The successions of habitats/ecosystems in Chaleur Bay highlight the fact that significant localized impacts at the level of a site could potentially affect the productivity/diversity of a “shared” ecosystem among sites. To address this uncertainty, a holistic approach will need to be used in assessing impacts when post-production AAR reports are presented to the department. The three individual site reports would need to be examined concurrently in order to fully consider the spatial extent of benthic impacts at the adjacent sites.

The present benthic footprint estimate does not include the physical parameters related to cleaner fish waste feed and feces, and so may be an underestimate. Additionally, an analysis of any benthic impact associated with the known high in-production mortality rates of cleaner fish (Geitung et al. 2020) has not been completed. Given the novelty of co-culturing Atlantic Salmon with cleaner fish species, limited information is known for such parameters.

The meeting did not review whether the nets will have sufficient depth to mitigate the effects of warm water temperatures on salmon. If the waters are well mixed, will the water at 30 m depth be sufficiently cool/oxygenated such that the bulk of the salmon in the cages can find areas with sufficiently low water temperatures to avoid stress and potentially subsequent disease/death? Related to this, is there a ‘reservoir’ of cold, well oxygenated subsurface water that will be accessible and of sufficient volume to pump, if necessary, during such warm water temperature events?

There is also no discussion provided to suggest that deeper cages will help mitigate the detrimental effect of cold water (superchill) events. Incidentally, it was noted that there are inconsistencies among the documents with some indicating that nets will be minimum 30 m depth while others state 20 m depth.

There are significant knowledge gaps regarding sea lice infestation levels in wild and farmed Atlantic Salmon. Monitoring and reporting of infestation levels and treatment frequency would improve knowledge of sea lice abundance and risk

Conclusions

Question 1: Based on the available data for the site and scientific information, what is the expected exposure zone from the use of approved fish health treatment products in the marine environment and the predicted consequences to susceptible species?

- The Benthic predicted exposure zone (benthic-PEZ) associated with the use of in-feed fish health treatment products resulting in the greatest intensity of impacts is within a radius of 2.1 km from the site location.
- There is an overlap between the feed-based benthic-PEZ for Friar Cove and Shooter Point with the adjacent sites. Any overlap between these anticipated zones suggest the potential for cumulative exposure to organic enrichment and feed chemical residues.
- The Pelagic predicted exposure zone (pelagic-PEZ) associated with the use of approved pesticides is within a radius of 6.9 km from the site location.
- There is a significant overlap of all the pelagic-PEZ related to the usage of bath pesticides. In particular, the pelagic-PEZ of Friar Cove and Shooter Point extend to water masses beyond Chaleur Bay. Considerations of the cumulative impacts of these pesticides in relation to the timing of their usage within the 3 sites to mitigate impacts on sensitive species is advised.
- Snow Crab, Toad Crab, shrimp, scallop and American Lobster are present in Chaleur Bay and therefore the sensitivity of larvae in the pelagic environment and juveniles in shallower waters to drugs and pesticides should be carefully considered during the application phase of operations to reduce potential impact on crustaceans recruitment.

Question 2: Based on available data, what are the species at risk, CRA species, ESS, EBSAs, and their associated habitats, within the predicted benthic exposure zone, that are vulnerable to exposure from the deposition of organic matter? How does this compare to the extent of these species and habitats in the surrounding area (i.e., are they common or rare)? What are the anticipated impacts to these sensitive species and habitats from the proposed aquaculture activity?

- The benthic-PEZ of organic matter associated with the greatest intensity of impacts is within a radius of 2.1 km from the site location, while the lightest particles could extend up to 33 km from the sites. These sites have relatively intact and diverse benthic habitats, with high concentrations of corals, sponges, and other fauna not previously reported for the area, and for which baseline data on vulnerability and recovery is lacking.
- Sessile or sedentary benthic taxa, including the soft corals, sponges, and other sessile organisms present at all three sites are expected to be more vulnerable to aquaculture wastes, as they cannot relocate to another environment when under stress. Although these species were usually identified outside of the proposed cage array, the overlap of the benthic-PEZ for Friar Cove and Shooter Point with the adjacent sites creates the potential for loss of these benthic assemblages due to aquaculture impacts in these overlapping areas.

- Although the proposed sites do not fall within any previously identified EBSA or SiBA, the soft coral gardens revealed by the video surveys at the Chaleur Bay and Friar Cove sites are considered unique in the region due to their perceived high density and importance as habitat for other species.

Question 3: To support the analysis of risk of entanglement with the proposed aquaculture infrastructure, which pelagic aquatic species at risk make use of the area, and for what duration and when?

- Leatherback Sea Turtles and large pelagic fish species (sharks and tunas) can be found in the area, particularly from spring to autumn. An increasing presence of large pelagic species in recent years suggests the potential for entanglements of sharks and tuna exists.
- The general area overlaps the distribution of several species of whales, including SARA-listed species (Blue Whale, Fin Whale and, North Atlantic Right Whale). Seasonally, the distribution of marine mammals is highest in nearshore Newfoundland waters from spring to autumn. While entanglement and subsequent drowning are the main concerns for marine mammal species, such as baleen whales which do not echolocate, the risk of entanglement is considered low at the proposed sites.

Question 4: Which populations of conspecifics are within a geographic range where escapes are likely to migrate? What are the size and status trends of those conspecific populations in the escape exposure zone for proposed site? Are any of these populations listed under Schedule 1 of SARA?

- Local populations of Atlantic Salmon, Common Lumpfish and Cunner are present within the geographic range where escapes are likely to migrate.
- COSEWIC (2010) designated the South Coast Atlantic Salmon population as Threatened. There have been longstanding and continuous population declines of wild salmon in southern Newfoundland as compared to other regions of the province. In 2019, total salmon returns to two monitored rivers in this region (Conne River and Little River) declined by 78% and 99%, respectively, compared to their previous three-generation average.
- There is genetic evidence that farmed salmon escapees are breeding with wild Atlantic Salmon in southern Newfoundland rivers. An assessment of the potential genetic impacts on Atlantic Salmon populations along the south coast of Newfoundland was completed based on the best available scientific data (North American and European) and the size and location of the existing and proposed sites. The proposed scale of expansion is predicted to result in an increased number of escapees in southern Newfoundland rivers, particularly near Chaleur Bay compared to present operations.
- Presently, there is no plan to monitor for the presence and distribution of escapees in the region, or for a traceability program to allow escapees to be assigned back to the producer. Industry supported monitoring and robust traceability programs are currently in place in other BMAs or jurisdictions in eastern North America. Without both of these components it remains difficult to evaluate containment success and claims that HDPE nets eliminate escapement, or to design and implement successful mitigation measures targeting genetic impacts of escapees on wild salmon in southern Newfoundland.
- COSEWIC (2017) designated Common Lumpfish as Threatened in Canadian waters. Although the specific locations of nearshore habitat use by nesting wild Common Lumpfish in inshore waters of southern Newfoundland are poorly understood, given the status of this species in the NL Region, and evidence of negative genetic impacts of cleaner fish on wild

populations elsewhere, the potential for increased negative interactions from the proposed expansion in southern Newfoundland is possible.

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Appendix A

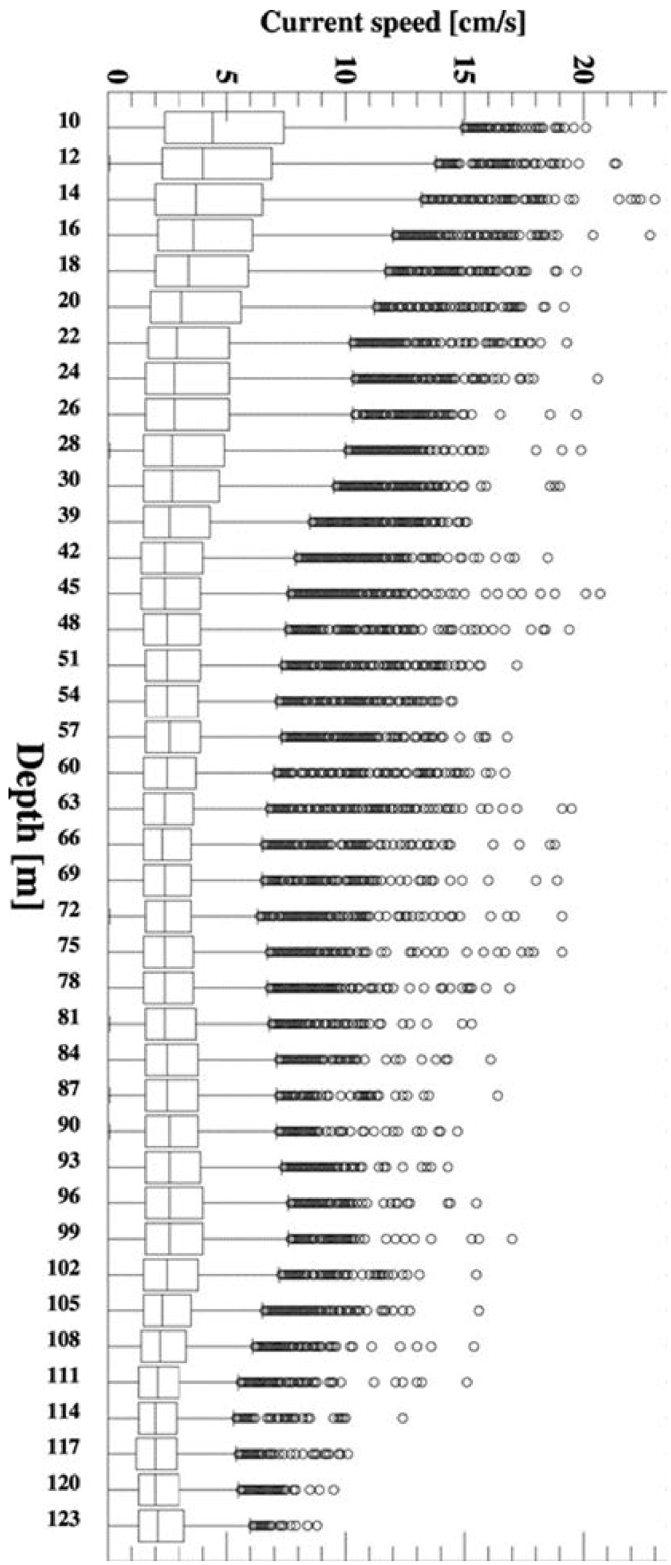

Figure A1: Boxplot of the current speed at different depths for Chaleur Bay.

Appendix B

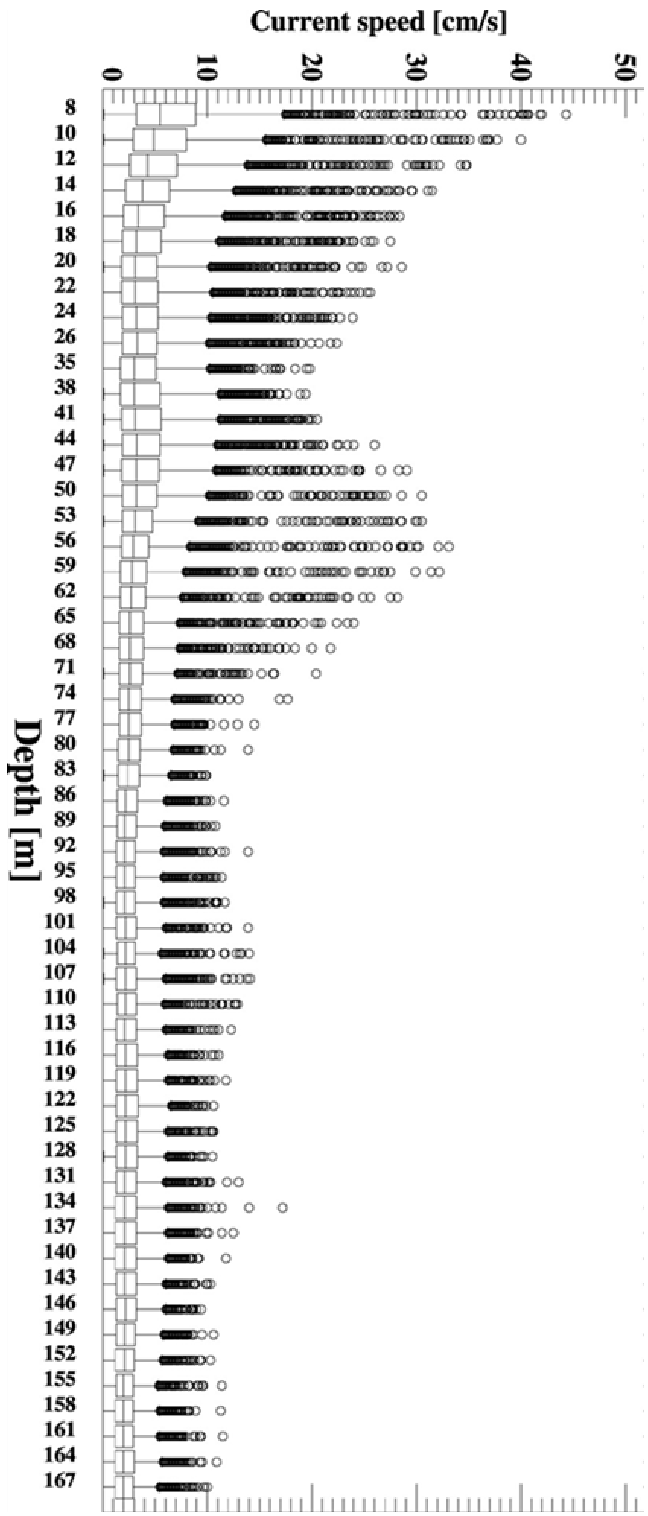

Figure A2: Boxplot of the current speed at different depths for Friar Cove.

Appendix C

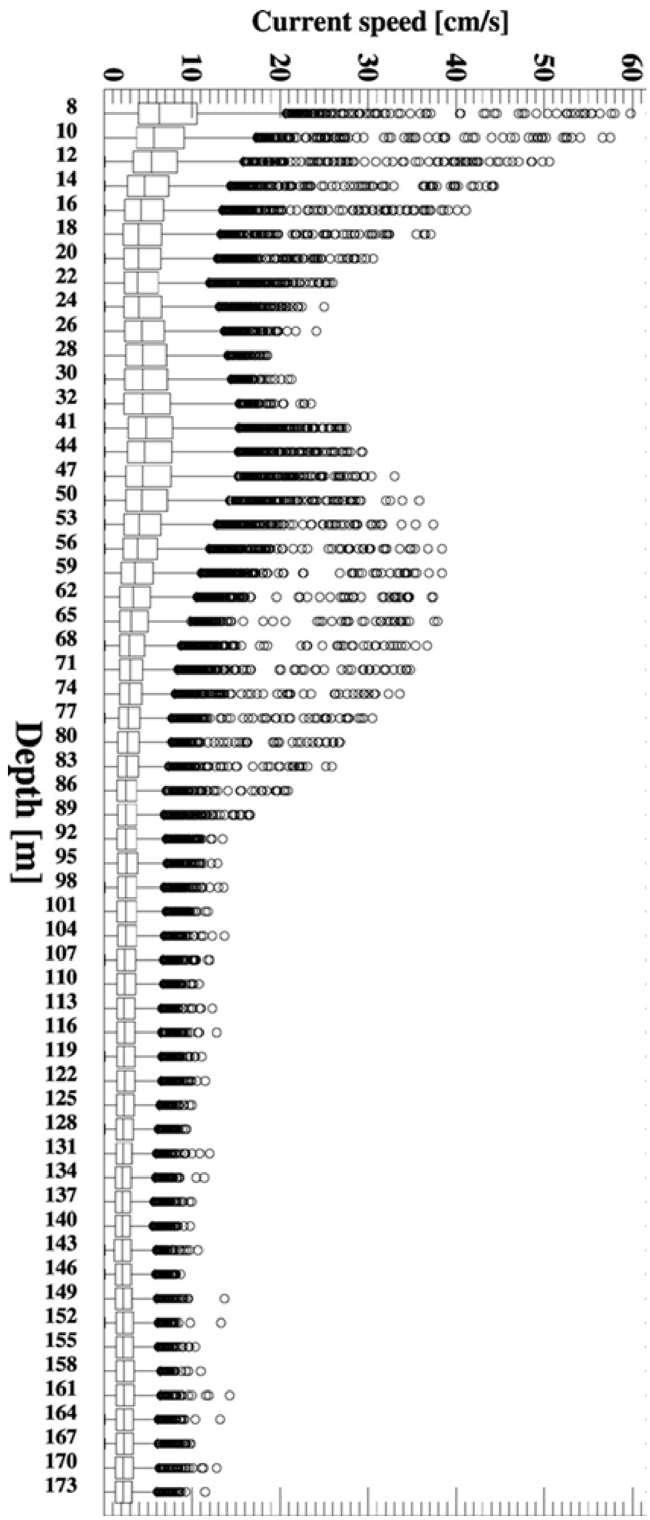

Figure A3: Boxplot of the current speed at different depths for Shooter Point.

This Report is Available from the:

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